

# Impact of 2.45 GHz Wi-Fi Radiation on Primordial Follicles in Female Rats: Protective Role of Folic Acid and Vitamin D

## Impacto de la Radiación Wi-Fi de 2,45 GHz en los Folículos Primordiales en Ratas Hembra: Papel Protector del Ácido Fólico y la Vitamina D

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**SUMMARY:** This study investigates the impact of 2.45 GHz Wi-Fi radiation on ovarian primordial follicles in female rats and explores the potential protective roles of folic acid and vitamin D. A total of 42 female offspring rats, derived from six experimental groups, were analyzed for histopathological, immunohistochemical, and biochemical changes following prenatal exposure to Wi-Fi radiation. Pregnant rats were exposed to Wi-Fi for 60 minutes daily throughout gestation, with folic acid and vitamin D administered to treatment groups at a dose of 5 mg/kg/day via oral gavage. Histopathological evaluation revealed a significant increase in atretic follicle count and a decrease in total follicle number in the Wi-Fi-exposed group compared to controls. Caspase immunostaining indicated increased apoptotic activity in the Wi-Fi group, whereas no significant difference was found between treatment and Wi-Fi-only groups. Biochemical analysis showed a significant reduction in Total Antioxidant Status (TAS) and an increase in Total Oxidant Status (TOS) in the Wi-Fi group, suggesting oxidative stress. However, folic acid and vitamin D did not significantly reverse these changes. No statistically significant alterations were observed in estrogen, Anti-Müllerian Hormone (AMH), or TGF- $\beta$ 1 levels across groups. In conclusion, prenatal Wi-Fi exposure may impair ovarian follicle development and induce oxidative stress in female rats. Neither folic acid nor vitamin D provided significant histological or biochemical protection under the tested conditions. Further studies are recommended to explore alternative antioxidants and varying exposure parameters.

**KEY WORDS:** Wi-Fi exposure; Folic acid; D vitamin; Total Oxidant Status; Total Antioxidant Status.

## INTRODUCTION

The use of technologies such as wireless communication devices has significantly increased in recent years. Wireless access has become a routine part of daily life in homes, workplaces, public areas, and schools. The widespread use of these technologies has also increased electromagnetic field exposure (EFE). Wireless communication devices are among the most common sources of electromagnetic fields (EF) that are used in close proximity to the human body. The literature indicates that tissues located closer to sources of EFE are more significantly affected (Kilgallon & Simmons, 2005; Hardell *et al.*, 2007). The reproductive system, in particular, is highly sensitive to the potential harmful effects of EFE. In female rats, the

number of primordial follicles is considered the foundation of fertility capacity. Primordial follicles are formed during the prenatal period and constitute the follicular pool that will be used throughout life. Therefore, damage to primordial follicles can lead to permanent and irreversible consequences for fertility. Data on the potential effects of EFE on ovarian reserve and follicular development are limited in the literature. However, some studies have reported that EFE reduces the number of primordial follicles in female rats and adversely affects ovarian reserve (Bakacak *et al.*, 2015).

While earlier research focused on the adverse health effects of electromagnetic fields emitted by mobile phones,

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current scientific interest is directed toward investigating the biological hazards of wireless devices such as Wi-Fi. Various studies have shown that biological systems may be sensitive to these forms of radiation (Otto & von Mühlendahl, 2007; Takahashi *et al.*, 2010; Çetin *et al.*, 2014; Dasadag *et al.*, 2015). In particular, the biological effects of 2.45 GHz EFE emitted by Wi-Fi networks have been the subject of numerous experimental studies in recent years. It has been suggested that EFE waves at this frequency range may trigger biological responses at the cellular level, such as oxidative stress and inflammation (Saygin *et al.*, 2018).

Despite the potential detrimental effects of EFE on follicular reserve and ovarian structures, studies highlighting the protective effects of antioxidants and supportive micronutrients are gaining attention. Especially folic acid and vitamin D have emerged as nutrients capable of protecting ovarian function by reducing radiation-induced DNA damage and oxidative stress, owing to their antioxidant properties and important regulatory roles in cell proliferation and differentiation. In the literature, administration of folic acid has been shown to significantly improve primordial follicle count, hormonal regulation, and reproductive success in response to low-dose radiation exposure (Zhang *et al.*, 2022). However, its specific effects on ovarian reserve have not been adequately investigated.

The aim of this study is to examine the effects of 2.45 GHz Wi-Fi-induced EFE on primordial follicles in female rats and to determine the protective roles of folic acid and vitamin D against these effects. The findings obtained in this context are expected to provide guidance for risk assessments in terms of reproductive health and contribute to the development of potential preventive strategies.

## MATERIAL AND METHOD

### Animals

In this study, a total of adult female Wistar Albino rats weighing 250–300 g and 42 female offspring rats aged 28 days, obtained from the pregnancies of these adult rats, were used. All rats were obtained from the Experimental Animals Research and Application Center of Kahramanmaraş Sütçü Imam University, Turkey. The animals were housed under standard laboratory conditions (22–23 °C room temperature, 50 % humidity, and a 12-hour light/dark cycle) in plastic cages. Food and water were provided ad libitum. All rats received the same drinking water and standard laboratory chow throughout the study. Starting from the 15th day of pregnancy, the pregnant rats were housed individually in separate cages.

The experimental protocols and procedures were approved by the Local Ethics Committee for Animal Experiments (protocol no: 2020-11, decision no: 02). All procedures were conducted in accordance with the guidelines and regulations of the Animal Experiments Ethics Committee of the Experimental Research and Application Center. The study was carried out in compliance with the Declaration of Helsinki.

### Experimental Design and Implementation Protocol

A total of 24 female rats were housed in separate cages away from male rats for a period of 20 days. Female rats confirmed to be non-pregnant were then housed with male rats for mating purposes. For mating, rats were placed in special cages at 17:00 in the evening, with a ratio of one male to two females, and kept together until 08:00 the next

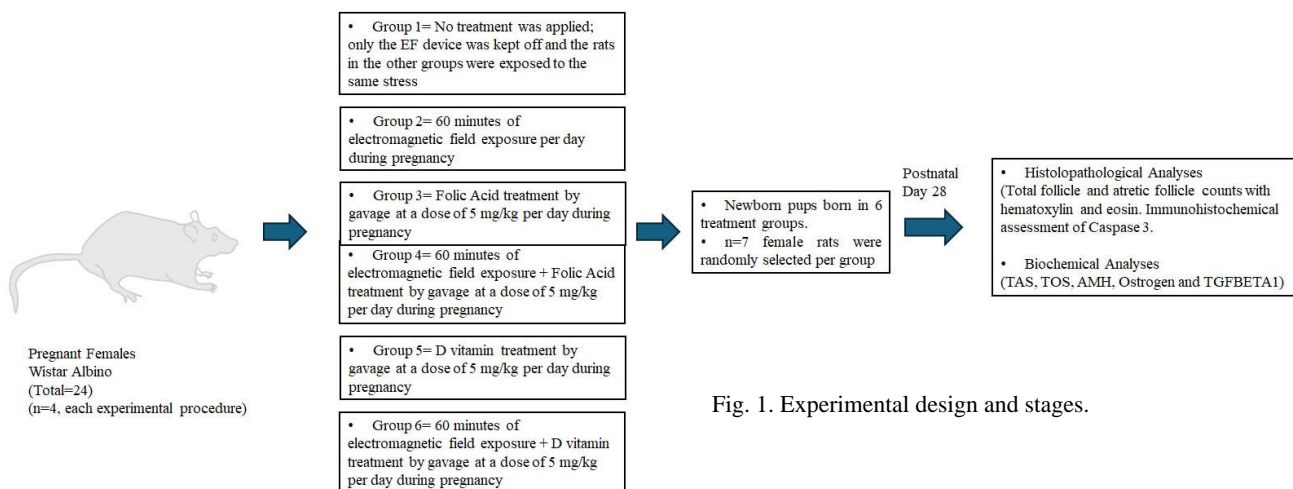


Fig. 1. Experimental design and stages.

morning. At the end of this period, the male rats were removed and placed in separate cages. On the following day, vaginal smears were collected from the female rats and examined under a microscope. Females with spermatozoa observed in their smear samples were considered to be 0.5 days pregnant.

Animals in the EFE groups were subjected to Wi-Fi radiation for 60 min daily (between 10:00–11:00) throughout the gestation period. Folic acid and vitamin D treatments were administered to the relevant groups via oral gavage at a dose of 5 mg/kg per day during pregnancy. The control group did not receive any treatment; however, they were exposed to the same level of environmental stress as the experimental groups, with the EF device kept turned off.

All groups and procedures related to the experimental design are illustrated in Figure 1. From each group, seven female offspring (a total of 42 offspring across six groups) were randomly selected and kept under appropriate laboratory conditions for 28 days postnatally. On day 28, the offspring were euthanized under anesthesia by excision of the ovarian tissues, and the samples were collected.

## Electromagnetic field exposure System Design

All EF exposures during the experiment were conducted in the application room of the KSÜ Experimental Animals Laboratory. To deliver EMF exposure to the rats, a cylindrical Faraday cage with a metal mesh surface, capable of housing four rats simultaneously, was used (Fig. 2). To minimize frequency leakage, the cage was wrapped in aluminum foil. A Very High-Speed Digital Subscriber Line (VDSL) modem device was positioned above the cage for 2.45 GHz experimental exposure. Specific Absorption Rate (SAR) values were calculated using the equation provided below.

$$SAR = \frac{\sigma E_i^2}{\rho}$$

Here,  $E_i$  represents the electric field intensity within the tissue,  $\sigma$  is the tissue conductivity, and  $\rho$  is the mass density of the equivalent tissue medium. The Specific Absorption Rate (SAR) was calculated as  $SAR_y = 2.011 \times 10^{-3} \text{ W/m}^2$ . The  $\sigma$  and  $\rho$  values used in the calculations can be found in the literature (Gabriel, 1996; Alchalabi *et al.*, 2017). After SAR calculations, the rats were placed in the cage in groups, and Wi-Fi exposure was applied from 20 cm (Fig. 2).

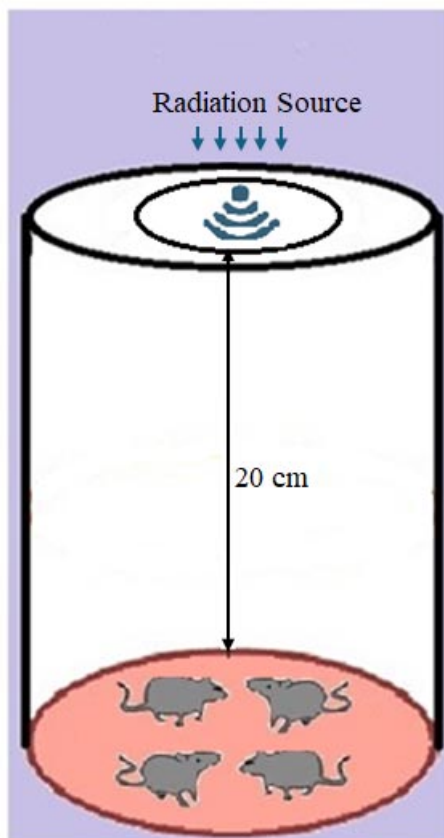


Fig. 2. Schematic drawing of the Faraday cage system.

## Histopathological Analysis Protocol

Following the weighing of the left ovary, the tissue was fixed in 4 % formaldehyde solution buffered with 0.1 M sodium phosphate at +4 °C for 24 h. Routine tissue processing was performed using an automated tissue processor (Leica TP 1020), and the samples were embedded in paraffin blocks using a Leica embedding system. Sections of 3–5  $\mu\text{m}$  thickness were obtained from the paraffin blocks using a rotary microtome (Leica RM 2125 RT) and mounted on slides (Sail Brand, Catalogue No: 7105). Hematoxylin-Eosin (H&E; Mayer's) staining and immunohistochemical staining for caspase were performed. Morphological evaluation was carried out under a high-resolution light microscope (Olympus DP-73 camera, Olympus BX43-DIC microscope; Japan).

Histopathological analyses were conducted by a blinded expert histopathologist. During the H&E evaluation, total follicle count and atretic follicle count were recorded. In the immunohistochemical evaluation for caspase, staining intensity was graded as follows: weakly stained (+,  $\leq 15\%$ ), moderately stained (++,  $\leq 30\%$ ), and strongly stained (+++,  $\geq 55\%$ ).

## Biochemical Analyses

Right ovary tissue samples designated for biochemical analysis were weighed and stored at  $-80\text{ }^\circ\text{C}$  until further use. On the day of the experiment, samples were thawed at +4 °C. The tissues were homogenized in Phosphate Buffered Saline (PBS, pH 7.4) using a homogenizer device (Analytik Jena SpeedMill P12). The homogenates were then centrifuged at 14,000 RPM for 10 minutes using pre-cooled centrifuge devices (Sigma 3k30 Centrifuge Manual and Hettich Mikro 220R Centrifuge Manual), and the supernatants were collected.

TAS (Total Antioxidant Status), TOS (Total Oxidant Status), TGF- $\beta$ 1 (Transforming Growth Factor Beta 1), AMH (Anti-Müllerian Hormone), and estrogen levels in the ovarian tissue samples were measured using commercially available rat-specific ELISA kits (Rel Assay Diagnostics®, Mega Tıp Ltd., Gaziantep, Turkey; product numbers: RL0017, RL0024...), following the manufacturer's instructions. The 96-well ELISA microplates provided with the kits were pre-coated with the respective capture antibodies. Standards and samples were added to the wells, followed by the addition of biotin-labeled detection antibodies and streptavidin-HRP conjugate for incubation. A substrate solution was then added to each well, and the enzyme-substrate reaction was terminated using an acidic stop solution. The resulting color was measured spectrophotometrically.

### Statistical Analyses

The normality of continuous variables was assessed using the Shapiro–Wilk test. Parametric methods were used for variables showing normal distribution, while non-parametric methods were applied to those not meeting

normality assumptions. For comparisons between two independent groups, Student's t-test or Mann–Whitney U test was used as appropriate. Data analyses were performed using Statistica version 13.3.1. A p-value of  $<0.05$  was considered statistically significant in all analyses.

## RESULTS

### Histopathological Findings

In the histopathological analyses, ovarian tissues were histologically scored, and all follicles and atretic follicles were evaluated across the entire tissue area for each group. A statistically significant difference was observed in the number of atretic follicles between the Wi-Fi group and the control group. When examining the total follicle count, a decrease in the number of follicles was observed in the Wi-Fi-exposed groups. However, no statistically significant difference was found in total or atretic follicle counts between the Wi-Fi groups and the Wi-Fi groups treated with either vitamin D or folic acid (Fig. 3). In the evaluation of caspase immunostaining, staining intensity was categorized as

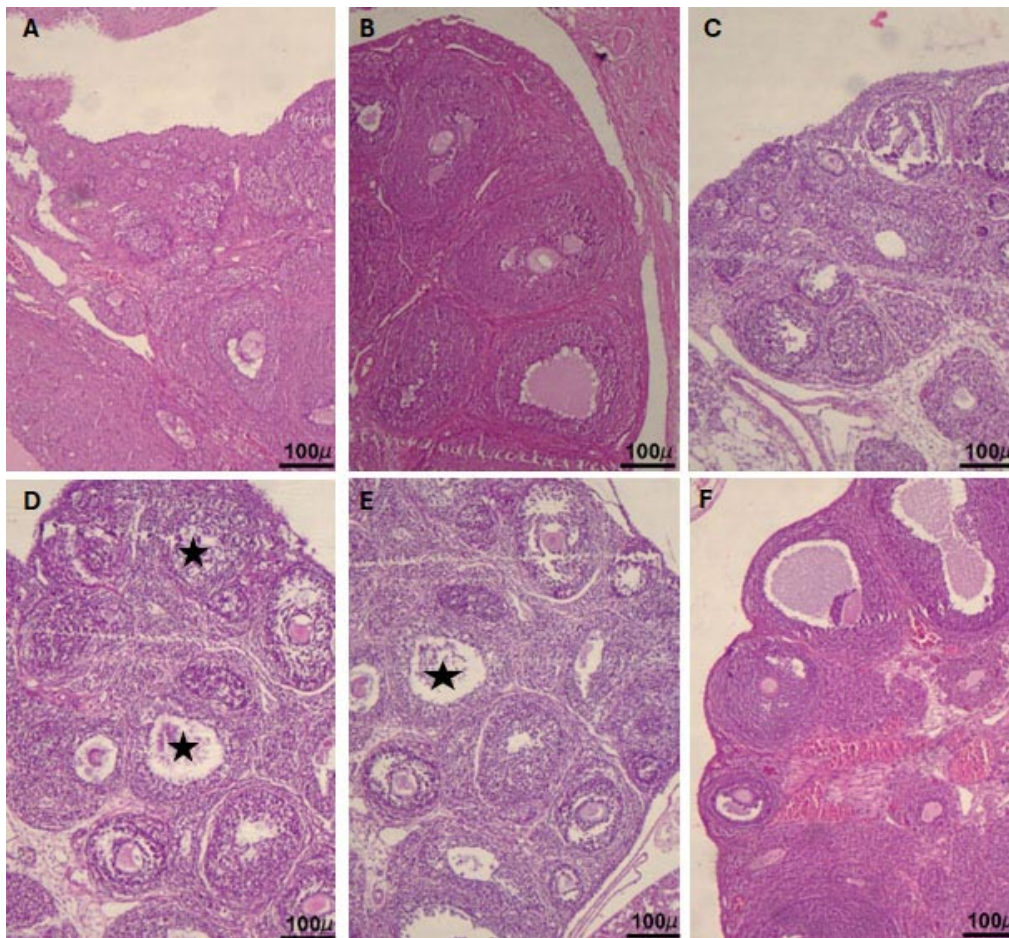


Fig. 3. Hematoxylin and Eosin staining. (A-F) Group 1-6, stars: appearance of atretic follicles, X100.

follows: low staining (+)  $\leq 15\%$ , moderate staining (++)  $\sim 30\%$ , and high staining (+++)  $\geq 55\%$ . Based on this assessment, significant differences in caspase-positive immunoreactivity

were observed between the control and Wi-Fi groups. No significant differences were detected between the treatment groups and the Wi-Fi groups (Fig. 4).

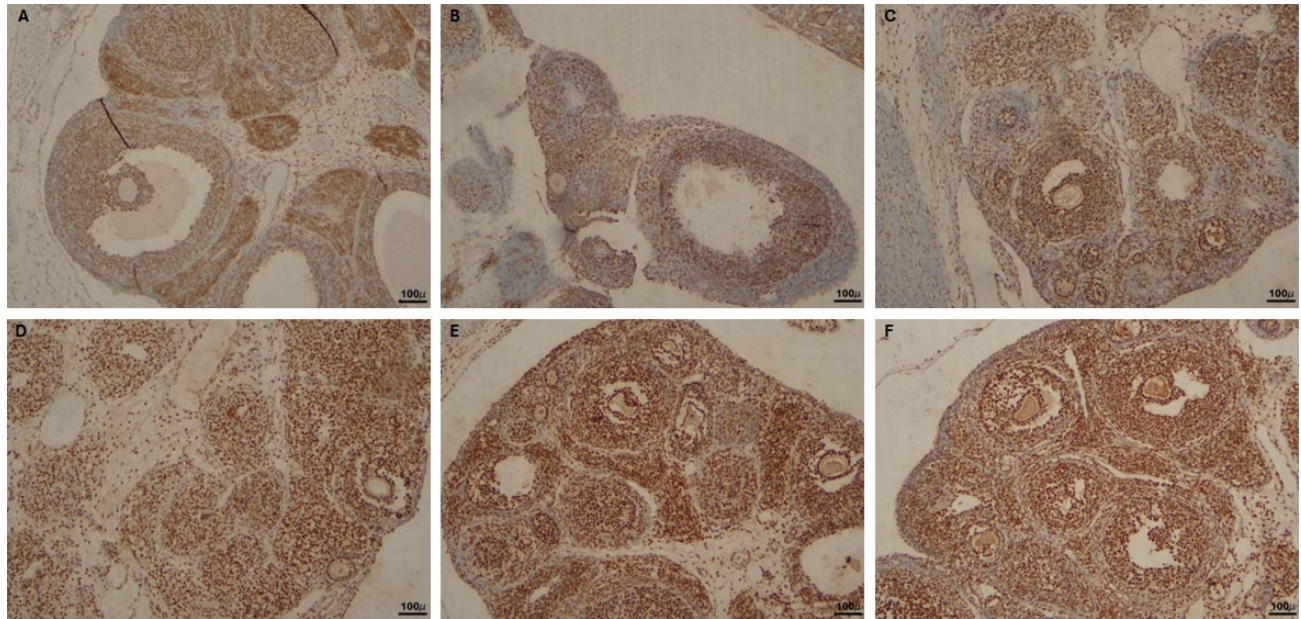


Fig. 4. Immunohistochemical analysis of caspase expression. (A-F) Group 1-6, X100.

### Biochemical Analysis Results

In our study, we evaluated the biochemical parameters of transforming growth factor beta (TGFβ1), estrogen, anti-Müllerian hormone (AMH), total antioxidant level (TAS), and total oxidant level (TOS) in female rat primordial follicles. The biochemical results of female rat primordial follicle tissue samples are shown in Table I. In terms of serum TAS (Total Antioxidant Status) levels, a statistically significant difference was detected in the Wi-Fi group

compared to the folic acid, vitamin D, and control groups ( $p = 0.037$ ,  $p = 0.010$ ,  $p = 0.002$ , respectively). Wi-Fi exposure resulted in a decrease in TAS levels compared to the control and non-exposed groups. However, no statistically significant difference in TAS levels was observed among the folic acid, vitamin D, and control groups, or among the Wi-Fi, Wi-Fi + folic acid, and Wi-Fi + vitamin D groups ( $p > 0.05$ ) (Fig. 5).

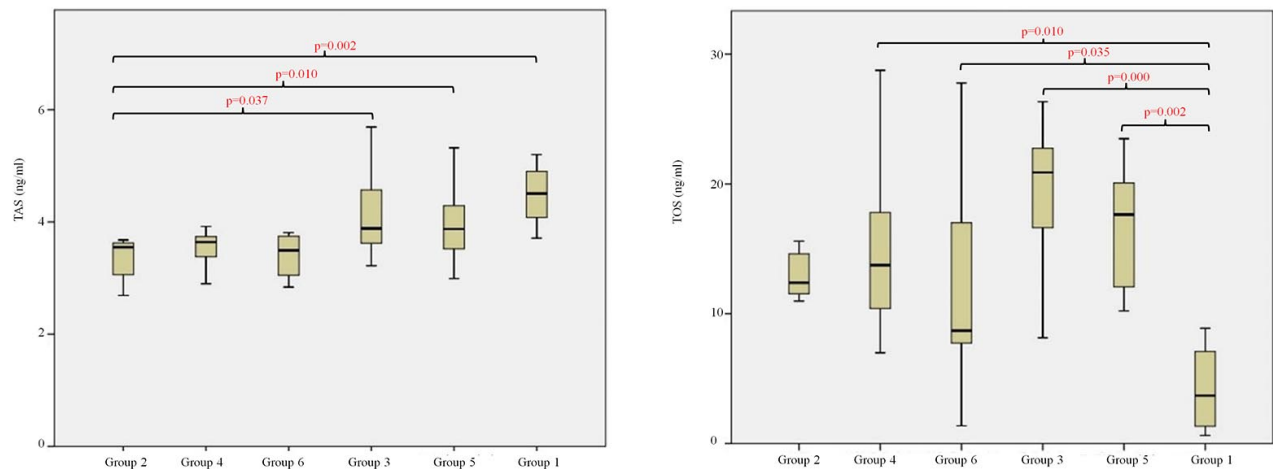


Fig. 5. Comparison of TAS and TOS serum levels between groups.

Table I. Biochemical results of female rat primordial follicle tissue samples.

Parameters	Group 1		Group 2		Group 3		Group 4		Group 5		Group 6	
	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max
TAS	4.59±0.73	3.71-6.19	3.33±0.44	2.69-3.68	4.18±0.87	3.22-5.69	3.55±0.35	2.9-3.92	4.12±1.0	2.99-6.32	3.40 ± 0.39	2.84-3.81
TOS	4.26±3.16	0.62-8.87	13.03±1.89	10.97-15.59	17.95±7.76	1.03-26.34	14.79±6.86	6.99-28.75	16.60±4.59	10.22-23.48	12.0±8.22	1.37-27.78
TGFBETA1	817.67±221.72	434.3-1087	685.21±94.33	615.6-842.9	818.75±90.18	601.6-926	744.03±141.61	567.2-938	735.07±117.08	512.1-926.2	838.94±229.5	407.2-1170
AMH	1.62±0.48	0.46-2.12	1.73±0.33	1.34-2.35	1.49±0.45	0.65-1.98	1.83±0.5	1.33-2.34	1.52±0.53	0.53-1.96	1.58±0.44	0.83-1.99
Oestrogen	531.51±122.41	270.3-652.9	551.24±91.30	440.6-716.6	519.44±118.70	421-832.7	510.32±213.99	262.2-998.3	558.70±138.96	368.7-811.8	635.19±158.82	408.9-820.2

Regarding serum TOS (Total Oxidant Status) levels, the control group showed a statistically significant difference when compared with the Wi-Fi, Wi-Fi + folic acid, folic acid, and vitamin D groups ( $p = 0.010$ ,  $p = 0.035$ ,  $p = 0.000$ ,  $p = 0.002$ , respectively). This finding is attributed to the lower TOS levels observed in the control group compared to the other groups. However, no statistically significant differences in TOS levels were found among the Wi-Fi, Wi-Fi + folic acid, Wi-Fi + vitamin D, folic acid, and vitamin D groups ( $p > 0.05$ ) (Fig. 5).

For TGFBETA1 levels, no statistically significant differences were found between the groups ( $p > 0.05$ ). Folic acid, vitamin D supplementation, and Wi-Fi exposure did not cause significant changes in TGFBETA1 levels. Although TGFBETA1 levels appeared lower in the experimental groups compared to the control group, this difference was not statistically significant (Fig. 6).

Similarly, no statistically significant differences were found among the groups in terms of estrogen levels ( $p > 0.05$ ). Folic acid, vitamin D administration, and Wi-Fi exposure did not significantly affect estrogen levels (Fig. 6).

There was also no statistically significant difference in AMH (Anti-Müllerian Hormone) levels between the groups ( $p > 0.05$ ). Folic acid, vitamin D supplementation, and Wi-Fi exposure did not result in significant changes in AMH levels (Fig. 6).

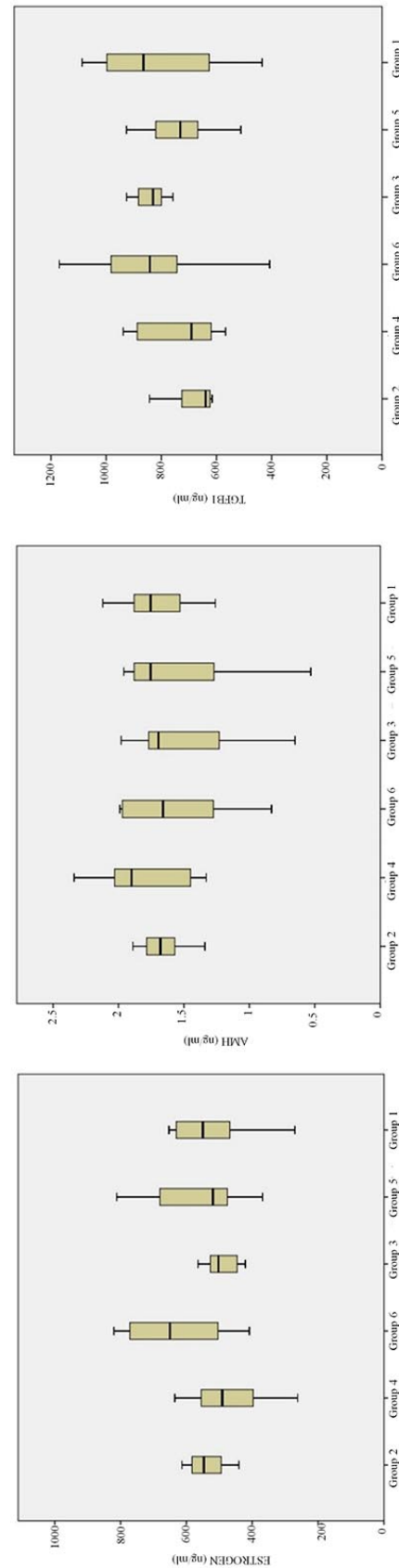


Fig. 6. Comparison of TGFBETA1, AMH and estrogen serum levels between groups.

## DISCUSSION

With ongoing technological advancements, wireless communication devices are now widely used in all areas of daily life, increasing the level of electromagnetic field exposure (EFE) in living environments. This rise in EFE has been shown to negatively impact human health, with several studies reporting its adverse effects on various organs and tissues (Salford *et al.*, 2003; Yan *et al.*, 2007; Nazıroglu *et al.*, 2013; Usikalı *et al.*, 2013; Oni *et al.*, 2019). Animal model studies have demonstrated a wide range of detrimental effects of EFE on reproductive functions.

At the cellular and molecular level, EFE has been shown to cause damage by altering membrane potentials and disrupting transmembrane ion transport (Salford *et al.*, 2003; Racuciu *et al.*, 2015). Specifically, research on the adverse effects of 2.45 GHz Wi-Fi radiation on the reproductive system has revealed significant structural and functional changes in ovarian tissues. Oni *et al.* (2019) reported that exposure to 2.45 GHz EFE during pregnancy reduced ovarian follicle reserves in first-generation albino rats, leading to follicular atrophy, disorganization, and a decrease in follicle count. Similarly, Usikalı *et al.* (2013) found that exposure to varying specific absorption rates (SAR) led to DNA band fragmentation and single-strand breaks in ovarian cells, as well as follicular morphological abnormalities, edema, and hyperchromasia. Roshangar *et al.* (2014) showed that low-frequency radiation caused structural deformations in oocytes and follicular cells, including irregular oocyte nests, nuclear shrinkage, heterochromatin formation, and cytoplasmic vacuolization. Ahmadi *et al.* (2016) also observed oocyte nuclear shrinkage and deformation due to EMF exposure, suggesting impaired folliculogenesis and oocyte implantation. In agreement with these findings, our study revealed a significant increase in atretic follicle count and a decrease in total follicle number in the Wi-Fi group compared to controls. Immunohistochemical analysis of caspase expression also showed a significant difference between the control and Wi-Fi groups, indicating increased apoptosis in ovarian tissues following EFE.

The biochemical alterations induced by EFE, particularly through oxidative stress, are well-documented. Increased oxidative stress and weakened antioxidant defenses are considered key indicators of cellular damage. In this context, we evaluated TGFβ1, AMH, estrogen, total antioxidant status (TAS), and total oxidant status (TOS) levels.

Previous studies reported that exposure to 2.45 GHz Wi-Fi radiation affected oxidative balance parameters in both pregnant rats and their offspring, decreasing estrogen levels

in mothers and glutathione peroxidase activity in offspring, while reducing TOS levels in both groups (Yüksel *et al.*, 2016). Similarly, Shahin *et al.* (2013) found that low-level microwave radiation reduced TAS values and overall antioxidant capacity in female mice. Contrarily, Kuybulu *et al.* (2016) showed that Wi-Fi exposure increased oxidative stress by elevating TOS levels and reducing TAS activity in kidney tissues of rat offspring. In our study, Wi-Fi exposure resulted in decreased serum TAS levels in female rats, while TOS levels remained unchanged. These findings suggest that Wi-Fi exposure disrupts the oxidative balance in primordial follicular tissues by weakening the antioxidant defense system, leading to increased oxidative stress and potential follicular damage. When evaluated collectively, existing literature indicates variable effects of EFE on oxidative stress markers across different tissues, with a general trend of suppressed antioxidant responses and disrupted redox balance—implicating EFE as a biochemical inducer of oxidative cellular damage.

In recent years, the use of protective agents against radiation-induced oxidative stress and cellular damage has become a major area of investigation (Kıvrak *et al.*, 2017; Mutavdzin *et al.*, 2019; Zhang *et al.*, 2022). One such agent is folic acid, known for its antioxidant properties and role in supporting cell regeneration. Experimental studies have demonstrated that administering folic acid (5 mg/kg) to female mice for three weeks prior to radiation exposure helps preserve ovarian follicular structure, regulate hormonal balance, and improve pregnancy rates. Folic acid has also shown neuroprotective effects in brain cells (Kıvrak *et al.*, 2017) and reduced oxidative damage in diabetic rats (Mutavdzin *et al.*, 2019). Furthermore, folic acid supplementation protected lung tissue against 900 MHz radiation in rats, maintaining alveolar, bronchiolar, and vascular integrity (Tüfekçi *et al.*, 2022). In another study, Zhang *et al.* (2022) reported that folic acid reduced ovarian atrophy and follicle loss in female mice exposed to 5 Gy X-ray radiation, increasing both follicle count and AMH levels.

Despite these promising findings, our study did not observe a significant difference in total or atretic follicle counts between the Wi-Fi-exposed group and the folic acid-treated Wi-Fi group. This suggests that folic acid, under our experimental conditions, may not offer a protective effect against Wi-Fi-induced ovarian damage. Similarly, due to a lack of prior studies evaluating the protective role of vitamin D against Wi-Fi exposure, comparisons with the existing literature were not possible. In caspase immunostaining analysis, no significant difference was observed between Wi-Fi-exposed and treatment groups, suggesting limited protective efficacy of both folic acid and vitamin D in this context.

The effects of low-frequency electromagnetic fields on reproductive and hormonal regulation have been reported with variable outcomes in the literature. Al-Akhras *et al.* (2008) demonstrated that 12-week exposure to low-frequency EMF significantly reduced progesterone and estrogen levels in adult female Sprague-Dawley rats. In contrast, our study found no significant impact of radiation exposure on AMH or estrogen levels. Similarly, no significant hormonal alterations were observed in folic acid or vitamin D-treated groups. These discrepancies may be due to differences in radiation intensity, exposure duration, or experimental protocols.

## CONCLUSION

The findings indicate that Wi-Fi exposure increases atretic follicle counts and decreases total follicle numbers. Folic acid and vitamin D supplementation did not significantly mitigate these effects. Additionally, Wi-Fi exposure did not significantly alter TGFβ1, AMH, or estrogen levels, but it did disrupt the TAS–TOS balance in primordial follicular tissues, weakening antioxidant defenses and increasing oxidative stress. No protective effect of folic acid or vitamin D was observed against these changes.

In conclusion, prenatal exposure to Wi-Fi radiation may have adverse effects on reproductive health. Future studies are recommended to investigate other antioxidant agents and different exposure conditions to explore potential protective strategies.

**Ethics Statement.** The experimental protocols and procedures were approved by the Local Ethics Committee for Animal Experiments (protocol no: 2020-11, decision no: 02). All procedures were conducted in accordance with the guidelines and regulations of the Animal Experiments Ethics Committee of the Experimental Research and Application Center. The study was carried out in compliance with the Declaration of Helsinki.

**KARABAS, S. A.; YOLDAS, A.; DAG, S. S.; YAYLALI, A.; ÇELİK, I. S. & SÖĞÜT, Ö.** Impacto de la radiación Wi-Fi de 2.45 GHz en los folículos primordiales de ratas hembra: Papel protector del ácido fólico y la vitamina D. *Int. J. Morphol.*, 44(2):645-653, 2026.

**RESUMEN:** Este estudio investiga el impacto de la radiación Wi-Fi de 2,45 GHz en los folículos primordiales ováricos de ratas hembra y explora el posible papel protector del ácido fólico y la vitamina D. Se analizaron 42 crías hembras de ratas, procedentes de seis grupos experimentales, para detectar cambios histopatológicos, inmunohistoquímicos y bioquímicos tras la exposición prenatal a la radiación Wi-Fi. Se expuso a ratas preñadas a Wi-Fi durante 60 minutos diarios a lo largo de la gestación. A los

grupos de tratamiento se les administró ácido fólico y vitamina D a una dosis de 5 mg/kg/día mediante sonda oral. La evaluación histopatológica reveló un aumento significativo en el número de folículos atresicos y una disminución en el número total de folículos en el grupo expuesto a Wi-Fi en comparación con el grupo control. La inmunotinción de caspasa indicó una mayor actividad apoptótica en el grupo Wi-Fi, mientras que no se encontraron diferencias significativas entre el grupo de tratamiento y el grupo solo expuesto a Wi-Fi. El análisis bioquímico mostró una reducción significativa en el estado antioxidante total (TAS) y un aumento en el estado oxidante total (TOS) en el grupo Wi-Fi, lo que sugiere estrés oxidativo. Sin embargo, el ácido fólico y la vitamina D no revertieron significativamente estos cambios. No se observaron alteraciones estadísticamente significativas en los niveles de estrógeno, hormona antimülleriana (AMH) ni TGF-β1 entre los grupos. En conclusión, la exposición prenatal al Wi-Fi puede afectar el desarrollo de los folículos ováricos e inducir estrés oxidativo en ratas hembra. Ni el ácido fólico ni la vitamina D proporcionaron protección histológica o bioquímica significativa en las condiciones evaluadas. Se recomiendan estudios adicionales para explorar antioxidantes alternativos y diferentes parámetros de exposición.

**PALABRAS CLAVE:** Exposición al Wi-Fi; Ácido fólico; Vitamina D; Estado oxidante total; Estado antioxidante total.

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